

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G02B 5/00, 5/04, 5/18 G01J 3/18	A1	(11) International Publication Number: WO 93/21548 (43) International Publication Date: 28 October 1993 (28.10.93)
--	----	---

(21) International Application Number: PCT/FI93/00150

(22) International Filing Date: 7 April 1993 (07.04.93)

(30) Priority data:  
921564

8 April 1992 (08.04.92)

FI

(81) Designated States: AU, CA, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

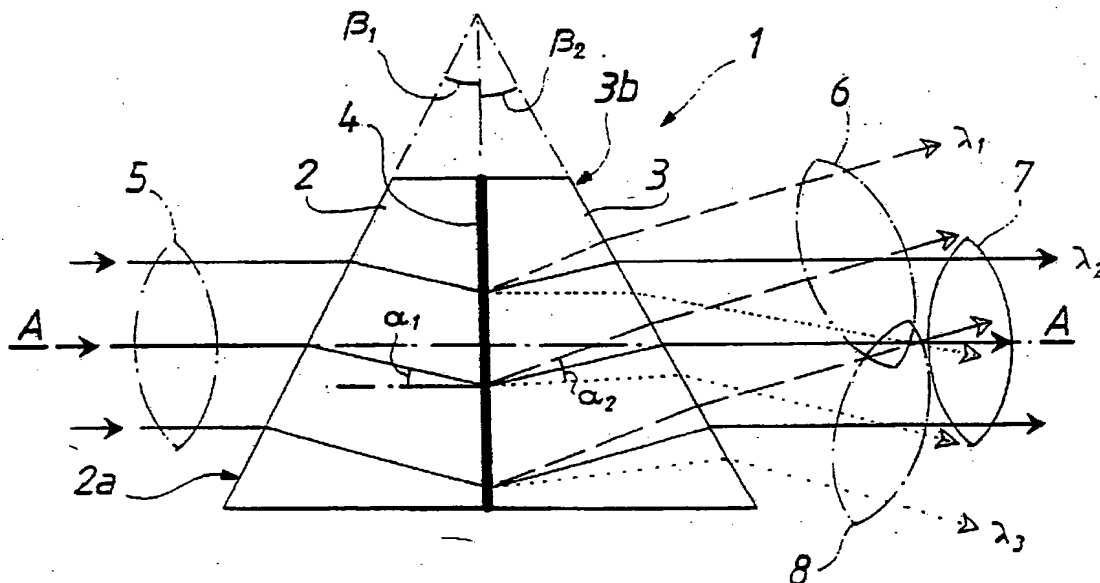
Published

With international search report.  
In English translation (filed in Finnish).(71) Applicant (for all designated States except US): VALTION  
TEKNILLINEN TUTKIMUSKESKUS [FI/FI]; Vuori-  
miehentie 5, SF-02150 Espoo (FI).

(72) Inventor; and

(75) Inventor/Applicant (for US only): AIKIO, Mauri [FI/FI];  
Ohjastie I C 3, SF-90540 Oulu (FI).(74) Agent: PAPULA REIN LAHTELA OY; Salomonkatu 17  
B, SF-00100 Helsinki (FI).

(54) Title: OPTICAL COMPONENT COMPRISING PRISMS AND A GRATING



(57) Abstract

The invention concerns an optical component (1), which comprises preferably two prisms (2, 3) and an intermediate transmission grating (4). The radiation is directed by means of the prisms (2, 3) and the radiation is dispersed or collated by means of a grating (4) with big dispersion to direct the wished radiation wavelengths into wished directions.

## OPTICAL COMPONENT COMPRISING PRISMS AND A GRATING.

The invention relates to an optical component.

5       According to prior art there is known optical components, such as a lense, a prism, a grating, with which optical radiation, such as radiation in the visible wavelength range and in the near infrared range can be processed, e.q. directed, collated and/or dif-  
10 fused into spectral parts. From these optical basic components it is known to assemble optical devices for processing radiation.

A drawback of using separate components, e.q. prisms and gratings and arranging them into lensesys-  
15 tems, is that carrying out the wished function requires an exact optomechanical implementation and also assembling and adjusting the apparatus. That is why the assembling of optical apparatuses from separate components in the mentioned way is very slow and expensi-  
20 ve.

The object of the present invention is to achieve a novel optical component, which eliminates the mentioned drawbacks. It is a particular object of the invention to achieve a novel component which can be  
25 used in several different apparatuses for processing optical radiation.

Regarding the features characteristic of the invention, reference is made to claim 1.

According to the invention the optical com-  
30 ponent comprises a combination of one or more prisms and a transmission grating, which is formed as a compact component, in which the radiation is directed with the prism or prisms and the radiation dispersion is acheived by means of the transmission grating to direct  
35 the wished radiation wavelengths into one or more wished directions.

According to the component of the invention

radiation is processed such that it can be diffused into wavelength components of the radiation directed into wished directions or conversely the radiation components coming from several sources can be collated into one compact radiation beam.

According to one aspect of the invention the optical component comprises two prisms and an intermediate transmission grating. This configuration is the minimum configuration of the optical apparatus to achieve the wished features.

According to one aspect of the invention the transmission grating is a holographic transmission grating of volume type.

According to one aspect of the invention the prisms are identical.

This invention has the following advantages. The mean advantage of the optical component is that by means of this component big optomechanical configurations can be constructed, in which among others things the optical and the mechanical axis of symmetry coincide. The optical component straightens the optical axis in the spectrograph. This gives advantages, especially in the picturing spectroscopy. Previously there has been utilized only prism configurations of "direct vision" type for implementing a spectrograph, but these have not been commonly utilized in measuring instruments, because the spectrum of these is too non-linear.

Still one advantage of the present invention is that the radiation is directed with one or more prisms and this gives a direct optical structure.

Still one advantage of the present invention is that combining into the prisms an intermediate dispersion element, e.g. transmission grating, gives the radiation passing through the optical component a big dispersion, which can be utilized in different applications.

Still one advantage of the present invention

is that the radiation spectrum can be arranged normal to the optical and the mechanical axis. Then the detector does not have to be inclined and thus the angle does not require exact controlling.

5 Still one advantage is that the present invention as such can be realized as a compact construction. This still facilitates the utilization of small size optical apparatuses.

The invention is described in the following in  
10 detail referring to the drawings attached, wherein:  
Fig 1 presents schematically one optical component according to the invention as a cross-sectional view;  
fig 2 presents an apparatus for registering several  
spectra;  
15 Fig 3 presents picturing spectroscopy;  
Fig 4 presents a monochromator;  
Fig 5 presents a wavelength multiplexer and -demultiplexer; and  
Fig 6 presents a spectrograph apparatus.

20 The optical component 1 in figure 1 comprises two prisms 2, 3 and a holographic transmission grating of volume type. The first prism 2 and the second prism 3 are identical and they have been arranged symmetrically on both sides of the grating 4. Thus the top  
25 angles  $\beta_1$ ,  $\beta_2$  of the prisms 2, 3 are equal, the thicknesses of the prisms are the same and they have been fabricated of the same material. The prisms 2, 3 and the grating 4 have been connected by their faces to a compact entity. The optical axis A-A of the optical  
30 component 1 passes symmetrically through the component normal to the grating 4.

The optical component 1 functions principally in the following way. The optical radiation is here passed essentially as a collimated radiation beam 5 to  
35 the first face 2a of the first prism 2, where the radiation is refracted according to Snell's law against the transmission grating 4 of volume type. The inci-

dence angle  $\alpha_1$  of the grating 4 is such that the wanted wavelength part  $\lambda_2$  passes into a wished direction  $\alpha_2$  after the grating. In the case of figure 1 the middle wavelength  $\lambda_2$  of the spectrum of the incidence radiation passes relatively to the optical axis A-A to the leaving face 3b of the second prism 3 and is directed outwards from the component as a leaving radiation beam 6 marked by a dashed line. Because the prisms 2, 3 are identical, the deflection of the radiation on the leaving face 3b of the second prism 3 relatively to the face 3b is symmetrical to the deflection of the radiation on the incident face 2b of the first prism 2. The leaving radiation beam 7 of this wavelength  $\lambda_2$  returns to a radiation beam radiating in the same direction as the original optical axis A-A.

By means of the grating 4 the relation between the propagation angle of the wavelengths  $\lambda_1$  and  $\lambda_2$  of the incident radiation 5 spectrum and the propagation angle of the middle wavelength  $\lambda_2$  is defined. The spectral part with the shortest wavelength  $\lambda_1$ , which belongs to the incident radiation beam 5, deflects the most in the optical component according to this and forms a leaving radiation beam 8, as can be seen from figure 1, the dashed line.

The optical component of figure 1 can be altered e.g. so that the top angles  $\beta_1$ ,  $\beta_2$  of the prisms are different in size and so that differing thicknesses and/or different materials are used in the prisms so as to change their refraction properties.

In figure 2 is presented an apparatus for registering several spectras simultaneously. Radiation is passed to this optical apparatus through photoconductors, e.g. a row of fibers 9, from several sources. The lense system 10 makes the radiation parallel so as to suite the optical component 1 of the invention. This optical component contains the same parts as in figure 1 and the same reference numerals have been used. Fol-

dence angle  $\alpha_1$  of the grating 4 is such that the wanted wavelength part  $\lambda_2$  passes into a wished direction  $\alpha_2$  after the grating. In the case of figure 1 the middle wavelength  $\lambda_2$  of the spectrum of the incidence radiation passes relatively to the optical axis A-A to the leaving face 3b of the second prism 3 and is directed outwards from the component as a leaving radiation beam 6 marked by a dashed line. Because the prisms 2, 3 are identical, the deflection of the radiation on the leaving face 3b of the second prism 3 relatively to the face 3b is symmetrical to the deflection of the radiation on the incident face 2b of the first prism 2. The leaving radiation beam 7 of this wavelength  $\lambda_2$  returns to a radiation beam radiating in the same direction as the original optical axis A-A.

By means of the grating 4 the relation between the propagation angle of the wavelengths  $\lambda_1$  and  $\lambda_2$  of the incident radiation 5 spectrum and the propagation angle of the middle wavelength  $\lambda_2$  is defined. The spectral part with the shortest wavelength  $\lambda_3$ , which belongs to the incident radiation beam 5, deflects the most in the optical component according to this and forms a leaving radiation beam 8, as can be seen from figure 1, the dashed line.

The optical component of figure 1 can be altered e.g. so that the top angles  $\beta_1$ ,  $\beta_2$  of the prisms are different in size and so that differing thicknesses and/or different materials are used in the prisms so as to change their refraction properties.

In figure 2 is presented an apparatus for registering several spectras simultaneously. Radiation is passed to this optical apparatus through photoconductors, e.g. a row of fibers 9, from several sources. The lense system 10 makes the radiation parallel so as to suite the optical component 1 of the invention. This optical component contains the same parts as in figure 1 and the same reference numerals have been used. Fol-

lowing the optical component 1 there is another lense system 11 in the propagation direction of the radiation. With this lense system 11 the radiation from the optical component 1 is directed towards the detector 12, which in this case is a matrix detector, e.g. a CCD matrix detector. The optical radiation can be passed to the apparatus of figure 2 through one or more photoconductors and the radiation spectras are registered with the said matrix detector 12. This apparatus is suitable for registering one or more spectras.

The picturing spectroscopical apparatus, which utilizes the optical component according to this invention, has been presented schematically in figure 3. This apparatus comprises an objective 13 and a slot 14, through which the radiation to be examined is passed to the first lense system 15 for making it parallel for the optical component 1 of the invention. Once again the optical component 1 is principally the same as in figure 1, and the same reference numerals have been used. The radiation leaving the optical component 1 is collated by means of the second lense system 16 and directed towards the detector, especially the matrix detector 17. The incident radiation can also be passed through other means to the first lense system 15 instead of the objective 13 and the slot 14.

A monochromator, which utilizes the optical component of the invention, has been presented in figure 4. A light source 18 has been formed through adjacent, light source components, e.g. LEDs laying in a row. The radiation leaving the light source 18 is collated by the first lense system 19 and is directed in a relatively small opening angle to the optical component 1 of the invention. Even in this case the optical component is a component according to figure 1, and the same reference numerals have been used. The radiation leaving the optical component 1 is collated with the second lense system 20, the desired part is filtered

away by means of the filter 31 and the remaining radiation is focused to the photoconductor 21, e.g. an optical fiber. Instead of the fiber 21 different mirror- and/or volume lense systems can be used for directing the radiation to the wanted site. Essential in the apparatus of figure 4 is that the light source 18 consists of several light source components, the radiation of which is collated by means of an optical component according to the invention to an essentially compact radiation beam.

The wavelength multiplexer is presented in figure 5. An optical radiation information from several sources is passed to this wavelength multiplexer through parallel photoconductors 23, e.g. a fiber row. Through each photoconductor 22 radiation of a different wavelength range can be brought. The radiation from the photoconductor 22 is collated by a first lense system 23 and directed to an optical component 1 according to the invention. The optical component 1 is once again the same as in figure 1, and the same reference numerals have been used. The radiation from the optical component 1 is treated with the filter 32, another lense system 24 and is directed to one photoconductor, e.g. a fiber 25. Alternatively it can also be directed to a photoconductor, a light channel etc. Further it is possible to process the radiation with other optical components, e.g. lenses, mirrors etc. to reach the goal.

A wavelength multiplexer of this type can be used in the opposite direction relatively to the mentioned propagation of the radiation. Then it functions as a demultiplexer. The optical radiation is passed through the photoconductor 25 to the apparatus and it is directed in a wished way to the photoconductor 22.

A small module type spectrograph apparatus is presented in figure 6. The radiation to be examined is in this case brought to the apparatus through the photoconductor 26. The photoconductor can e.g. be a multi-form

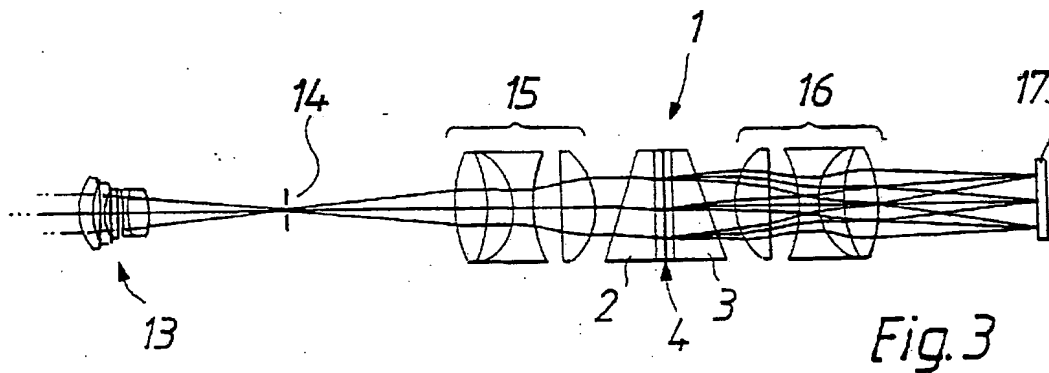
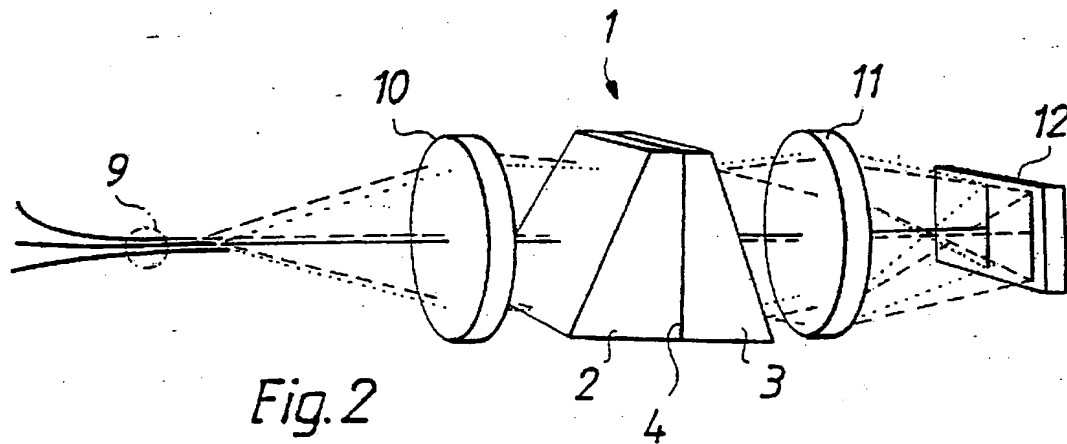
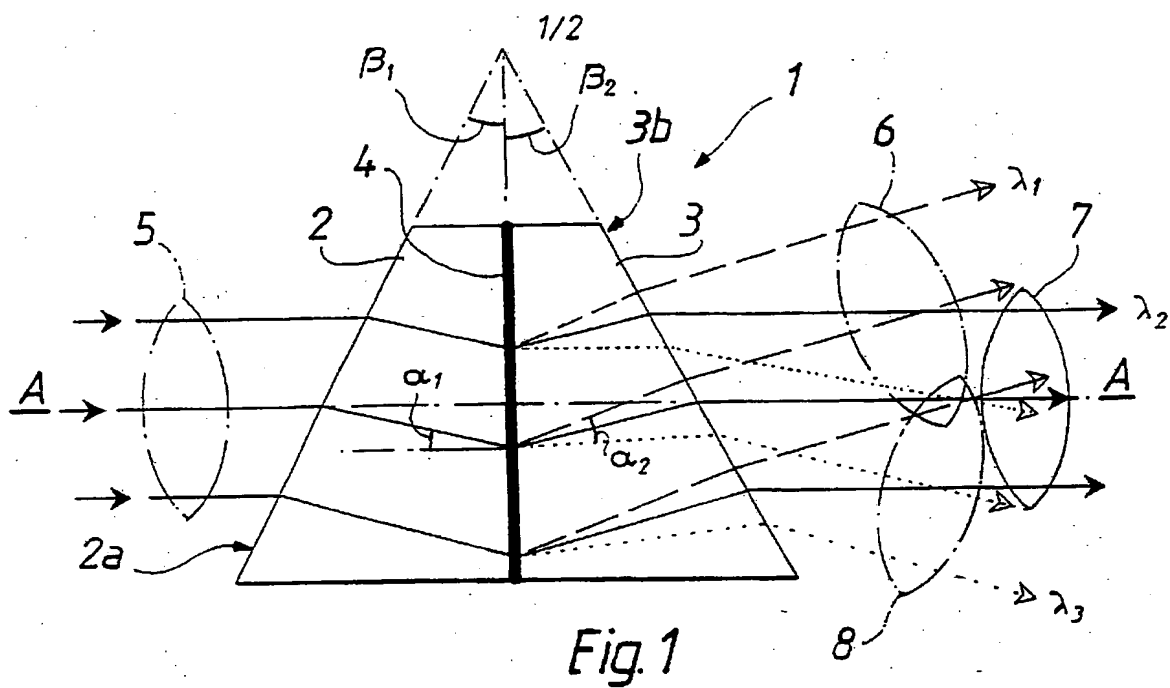


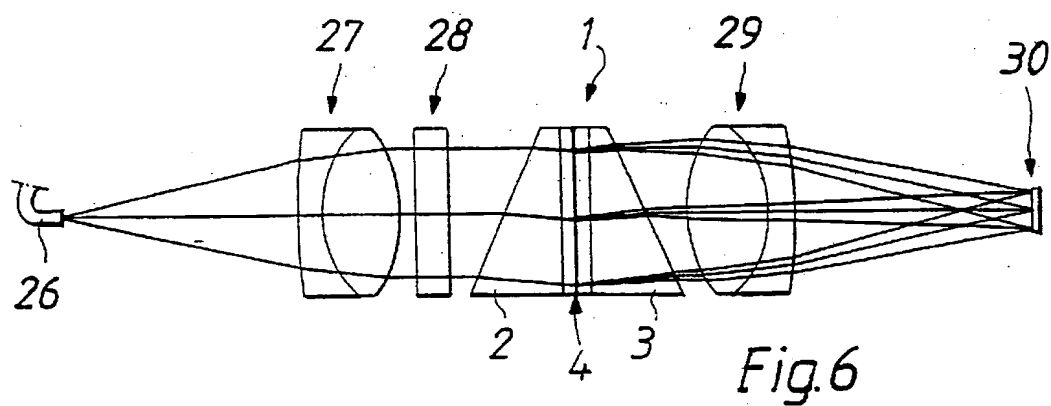
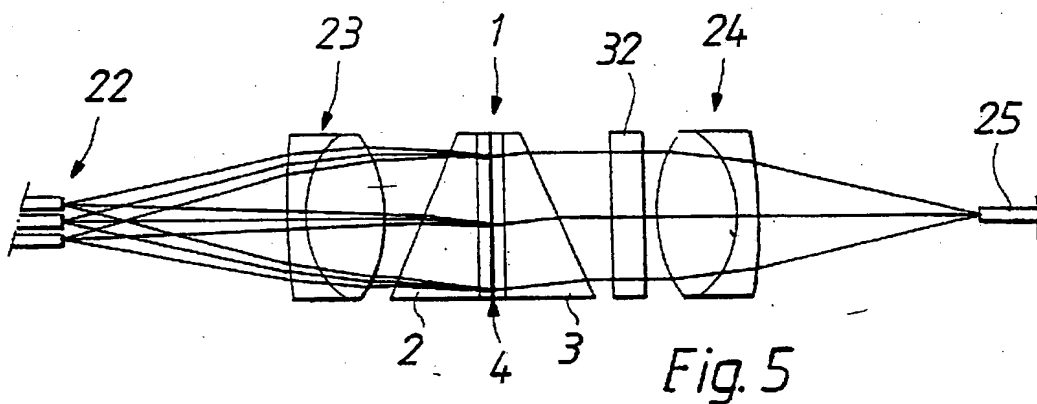
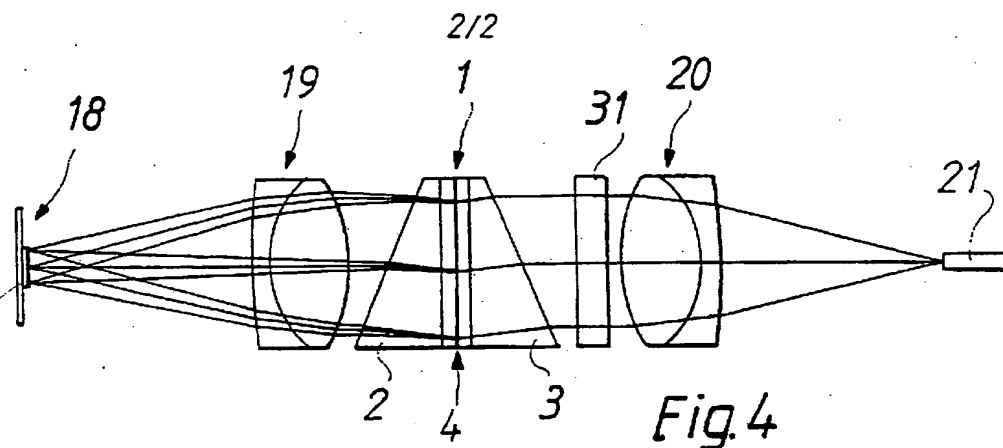
fiber, which is connected to the apparatus through a FC-connector. The radiation from the photoconductor 26 is collimated with the first lense system 27, after which it is passed to a high pass filter 28. Then the radiation is brought to travel through an optical component 1 according to this invention. This apparatus is principally the same as that one, which was presented in figure 1, and the same reference numerals have been used. Following the optical component 1, the radiation is collated by another lense system 29, and directed to a detector 30. A spectrograph apparatus of this type works e.g. on the wavelength range 750 - 1065 nm and has a resolution of e.g. 20 nm. The high pass filter 28 prevents all wavelengths under 650 nm to travel into the apparatus. The detector 30 can be a row detector, which is a per se known semiconductor detector. This consists e.g. of 16 elements. On this element a spectra is formed from the incident radiation and registered.

The embodiment examples are meant to illustrate the invention and embodiments of the invention may vary within the scope of the claims following below.

## Claims:

1. Optical component, characterized in that the component (1) comprises a combination of one or more prisms (2, 3) and a transmission grating (4), which is formed as a compact component, where the radiation is directed by means of the prism or prisms (2, 3) and the radiation dispersion is achieved by means of the transmission grating (4) to direct the wished radiation wavelengths into one or more wished directions.
2. Optical component according to claim 1, characterized in that component (1) comprises two prisms (2, 3) and an intermediate transmission grating (4).
3. Optical component according to claim 2, characterized in that the transmission grating (4) is a transmission grating of volume type.
4. Optical component according to claim 2 or 3, characterized in that the prisms (2, 3) are identical.





## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 93/00150

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: G02B 5/00, G02B 5/04, G02B 5/18, G01J 3/18  
 According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: G02B, G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPAT

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4475792 (LOUIS SICA, JR), 9 October 1984 (09.10.84)	1
A		2-4
A	US, A, 5002390 (EDGAR GERLACHER ET AL), 26 March 1991 (26.03.91)	1-4

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

## \* Special categories of cited documents

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

\*&\* document member of the same patent family

Date of the actual completion of the international search

15 July 1993

Date of mailing of the international search report

19 -07- 1993

Name and mailing address of the ISA/  
 Swedish Patent Office  
 Box 5055, S-102 42 STOCKHOLM  
 Facsimile No. +46 8 666 02 86

Authorized officer

Bertil Dahl  
 Telephone No. +46 8 782 25 00

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**